Refrigerant Charge Verification: 70°F Return Air Requirement

This article describes a method for maintaining air conditioner return air dry-bulb temperature above 70°F while performing refrigerant charge verification when the outdoor temperature is between 55 and 65°F, in accordance with the protocol in 2008 Reference Residential Appendix RA3.2. Maintaining return air dry-bulb temperature greater than 70°F has been an explicit requirement since the refrigerant charge verification protocol was first adopted in conjunction with the *2001 Building Energy Efficiency Standards*; this was determined to be necessary to achieve reliable test results and to avoid the possibility of freezing the indoor coil and damaging the air conditioner.

Keeping the return air dry-bulb temperature above 70°F can be achieved either by operating the central heating system to preheat the dwelling sufficiently to keep the air temperature above 70°F for the duration of the test, or by using supplemental electric resistance heating devices. In practice, it is likely that both preheating and supplemental heating will be necessary.

Supplemental heating provides two benefits useful for maintaining the return air temperature above 70°F. Consider both of these effects when selecting supplemental heat sources in a specific situation:

1. The addition of heat to the conditioned air slows the overall rate of cooling of the *dwelling's mixed air* during the test, extending the time the dwelling air temperature can stay above 70°F.

2. If the heat is added to the airstream close to the entrance of the return grille/plenum such that most or all of the heat is drawn into the air handler's return airstream, the return plenum receives a localized temperature boost. Thus the plenum air temperature can be maintained at a temperature that is greater than the temperature of the dwelling's mixed air. Ultimately, it is the *return plenum air temperature* that must be maintained above 70°F during the test since the return air temperature is measured in the return plenum.

Electric resistance convection room heaters or hair dryers widely available with a 1,500 Watt capacity are suitable for use in a 110 Volt, 15 Amp circuit, of which there are likely to be 4 or more in a dwelling. By use of extension cords, each heater can be plugged into a separate circuit. Also, many dwellings are likely to have a 30 Amp, 220 Volt electric clothes dryer plug-in receptacle that could be used to power a 4,000 to 6,000 Watt portable heater.

Whenever possible, the air in the dwelling should be preheated to raise it to a temperature that is substantially higher than 70°F (e.g., 75 to 80°F) before the air conditioner is turned on for the refrigerant charge test. This preheating is best accomplished by the central heating system, but a plug-in electric heater could also be used. When the air conditioner is turned on for the test, the dwelling air temperature will begin to fall steadily. If the dwelling air temperature does not drop to 70°F before the end of the test, no supplemental heating is needed. However, it will probably be necessary to use supplemental heat to counteract the cooling of the dwelling air during the test to keep the temperature of the return air above 70°F. The amount of supplemental heating needed to keep the return air temperature above 70°F during the refrigerant charge test depends on the cooling capacity and airflow rate of the air conditioner, and numerous other factors.

There will likely be a nominal 15 to 20°F temperature drop of the airflow as it moves across the cooling coil when the cooling system is operating properly. Addition of supplemental heating to the conditioned air will counteract a portion of the cooling effect that the air conditioner has on the air temperature in the dwelling, thus *extending the time* that the dwelling air temperature will remain above 70°F. For example, for an air conditioner that produces a nominal 20°F temperature drop across the cooling coil, the addition of supplemental heat at the return grille that creates a 10°F temperature increase of the return airstream will counteract half of the air conditioner's cooling capacity, thus approximately doubling the time the dwelling air temperature remains above 70°F.

Additionally, placing the supplemental heating device(s) close to the return air grille such that most or all of the heat is drawn immediately into the return airstream yields the added benefit of providing a localized temperature boost in the return air plenum, as the heat is not yet mixed into the total volume of the air in the dwelling.

The concepts described above are illustrated in an example shown in Figure 1. The following paragraphs describe what is shown in the graph:

- Line A shows the change in air temperature over time in a dwelling that has been preheated to 75°F when the air conditioner is turned on to perform the refrigerant charge test. The temperature of the return air drops at a rate of 0.5°F per minute, thus at point "a" ten minutes after turning on the air conditioner, the temperature of the return air is 70°F. The test protocol requires that the return air temperature remain above 70°F for at least 15 minutes, so this test is not valid.

- Line B shows the change in air temperature over time in a dwelling that has been preheated to 75°F, in which the addition of supplemental heating has reduced the cooling effectiveness of the air conditioner. In this example the cooling effectiveness has been reduced such that the length of time that the dwelling air stays above 70°F is increased to almost 15 minutes (see point "b").

- Line C, which occurs simultaneously to Line B, shows the additional effect of placing the supplemental heating close to the return air grille such that most or all of the heat is drawn directly into the return plenum. Note that Line C has the same slope as Line B, indicating the same rate of cooling of the dwelling air, but that there is a 4°F increase of the return plenum air temperature. Thus, the return plenum air temperature remains above 70°F for more than 25 minutes even though the dwelling air temperature does not (see point "c"). This would likely be sufficient time to complete the test.

Table 1 provides general guidance for expected impacts on return air temperatures based on nominal air conditioner airflow rates and supplemental electric heating capacities. Electric energy inputs are shown in 1,500 Watt increments corresponding to the power ratings of commonly available small electric resistance heating appliances. The actual temperature impacts resulting from applying supplemental heat in the field may vary from dwelling to dwelling, since actual system airflow and cooling capacity, outdoor temperature, envelope and duct leakage, and other cooling load-related variables may affect the rate of temperature change in the dwelling during the process. Experience with these procedures will be necessary to select the optimum amount of supplemental heat for a valid test.

Two examples making use of Table 1 are provided below.

Example1: For a nominal 3-ton system (1,200 cfm), when two 1,500 Watt convection heaters (3,000 Watts total) are placed near the return air grille such that most or all of the heat is drawn into the return airstream, the temperature of the airstream entering the return plenum will increase by approximately 7.9°F. Since the air conditioner can still cool the air in the dwelling during the test even with the addition of this supplemental heating, the dwelling should be preheated before starting the test to a temperature that is high enough to keep the return plenum air temperature above 70°F. Thus, the temperature of the mixed air in the dwelling needs to remain above 62.1°F (70 - 7.9 = 62.1) for the duration of the test and the preheating of the dwelling air must be sufficient to ensure that happens; otherwise, additional supplemental heat must be used.

Example 2: For a nominal 3-ton system (1,200 cfm), when a 6,000 Watt convection heater is placed near the return air grille such that most or all of the heat is drawn into the return airstream, the temperature of the airstream entering the return plenum will increase by approximately 15.8°F, thus counteracting most, if not all, of the air conditioner’s cooling capacity. If the supplemental heat is sufficient to prevent the temperature of the mixed air in the dwelling from falling to 54.2°F (70 – 15.8 = 54.2) during the test, preheating the dwelling air will not be necessary.

Note: It is the responsibility of the contractor or rater to ensure that the methods suggested in this article are performed safely.

Figure 1. Example using electric resistance heat added at return grille.

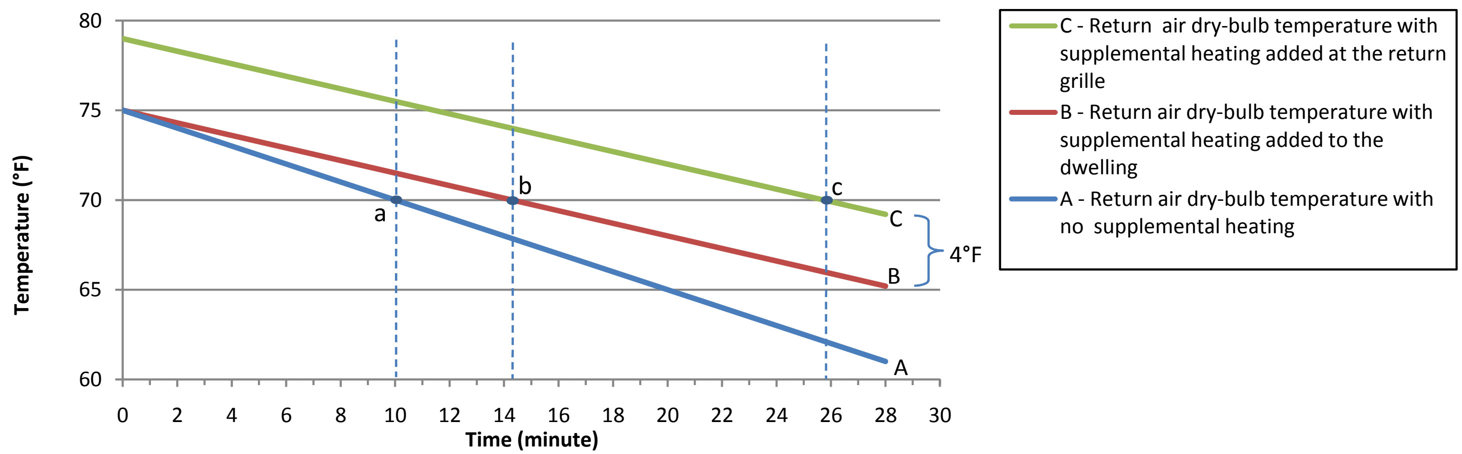

Table 1. Nominal retun plenum airflow temperature increase - ΔT Airflow (°F) - due to electric resistance heat added at return grille.

Nominal Cooling Capacity (ton)		2	2.5	3	3.5	4	5
Nominal System Airflow (cfm)		800	1000	1200	1400	1600	2000
Energy Input (Watt)	1,500	5.9	4.7	4.0	3.4	3.0	2.4
	3,000	11.9	9.5	7.9	6.8	5.9	4.7
	4,500	17.8	14.2	11.9	10.2	8.9	7.1
	6,000	23.7	19.0	15.8	13.5	11.9	9.5
	7,500	29.6	23.7	19.8	16.9	14.8	11.9
	9,000	35.6	28.4	23.7	20.3	17.8	14.2

note: Energy Input (Watt) * 3.413 (Btuh/Watt) /(1.08 * cfm) = ΔT Airflow